CORRESPONDENCE

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COLOUR BLINDNESS

To the Editor, The Eugenics Review

Sir,—Professor Pickford's most interesting article "Natural Selection and Colour Blindness"[1] must set many readers thinking anew about the problem of this polymorphism. The following comment may therefore have some value, for it underlines the necessity of considering that quite complex selection must be considered wherever polymorphism is involved, with the possible exception of polymorphisms *solely* dependent on heterozygous advantage. Furthermore, the hypothesis suggested is open to experimental investigation. I would like to stress that my comment is not made in any sense of criticism of Professor Pickford's article.

Professor Pickford's discussion only considers directional selection thus implicitly treating colour blindness as a transient polymorphism, except in so far as it may be maintained by heterozygous advantage. Yet it is clearly a balanced polymorphism and there is no good reason for supposing heterozygous advantage to be the sole or even an important factor in its origin or even maintenance. Many such balanced polymorphisms seem likely to have originated through disruptive selection, and I would like to suggest colour blindness in man may be one.

Disruptive selection will occur whenever two or more phenotypes in a population are in any way interdependent, that is when they contribute to one another's fitness,[2] and has been shown to have striking effects.[3] In these circumstances, of two alleles, one will be the fitter when it is below a certain frequency and the less fit when above that frequency.

Now anyone with deep experience of interpreting aerial photographs for military purposes will know that much of the most useful information is unobtainable from colour photographs, monochrome photography being essential. Some additional information is obtainable from colour photography but, at least in the 1939-45 war, its value was insufficient to justify its use. There is therefore the possibility that, in some circumstances, some types of useful information might be obtained more readily by the colour blind. A group of individuals who could *communicate* might therefore obtain more information if some of its members were colour blind and others not. This might well apply to a hunting group, the colour blind individuals contained in it perhaps being better at spotting certain kinds of predator and prey, the colour perceptive being better at spotting other kinds. In a food gathering and hunting economy, if the food gathering were largely done by females—colour blind male children being protected from gathering wrong food by their mothers—and the hunting by males, a sex-linked polymorphism would seem appropriate. It seems worth considering the possibility that the colour blind polymorphism in man had this kind of origin.

Quite simple experiments can be suggested as tests of the plausibility of such speculations. The relative success of colour blind and non colour blind individuals at recognizing eggs in colour and in black and white photographs of areas of moor or sand dune, some containing some not containing birds' nests, could be measured: likewise with photographs of rabbits, snakes, young birds, different berries, and so on. Similar experiments could be done in the field. If these experiments showed that colour blind individuals have certain advantages when trying to detect camouflaged natural objects, then the relative success of pairs of colour perceptive, pairs of colour blind, and mixed pairs at searching an area of dune or moorland for such objects could be investigated. If on the average the mixed pairs prove the more successful the hypothesis would be given support.

Such an hypothesis might explain the origin of the polymorphism. It would not necessarily explain the increase of colour blindness frequency with civilization that Professor Pickford was concerned with. However, the basic concept that it may be a positive advantage to a group to contain both phenotypes should also be considered when explanations of these data are sought. At the same time, it should not be forgotten that both disruptive selection, directional selection, and heterozygous advantage may be operating together, so that while disruptive selection might explain the original polymorphism and even the origin of hetero-

zygous advantage, changed intensities of selection could account for changing frequencies. Relaxation of the greater selection against colour blindness might well lead to rise in frequency especially if long maintenance of the original polymorphism by disruptive selection had resulted in the evolution of some heterozygous advantage. But we should not forget that such a conclusion may be wrong, for we neither know anything of the situation in civilized communities, nor can we be sure that the relative gene frequencies in hunting-food gathering ancestors of Causasian whites were similar to those of contemporary peoples having such economies. Concerning this latter point, under the disruptive selection system I have suggested, the optimum gene frequencies would vary not only according to the relative frequency of food, poisonous berries etc., and predators more readily recognized by colour blind and those more readily recognized by colour perceptive individuals, but also according to the usual size of the hunting group (for gene frequency must be high enough to make it likely that the usual size group contain at least one of the rarer type). Both these factors may have differed in different parts of the world.

With regard to civilized communities it is difficult to guess. As yet little thought has been given to the concept that *variety* of genotype has value in a socially organized population, and little factual evidence is available, though colour blind individuals are used for certain jobs in the dyeing industry and it is also useful to have a colour blind worker in a *Drosophila* genetics laboratory! It may be that civilized communities actually profit more from their colour blind individuals than Neolithic communities did, so that there is disruptive selection maintaining the polymorphism now with the advantage set at a higher frequency of colour blindness than in earlier times. Only critical investigation into both the advantages and the disadvantages of colour blindness and colour perception could provide evidence on the question. Until we have such evidence it will be dangerous only to consider relaxed selection as a possible cause of the higher frequencies of colour blindness in Caucasian whites.

There is one error in Professor Pickford's article to which I feel I must draw attention, because it is an error that has been made before in other contexts. In his introductory paragraph he remarks that colour vision was lost in the evolution of mammals, and re-evolved in the Primates. The evidence for this statement is presumably that some reptiles have colour vision. However, it is generally thought that reptiles are at least a diphyletic class. Living reptiles are related to the group that gave rise to birds. The group of reptiles that gave rise to mammals is extinct. Study of living reptiles cannot therefore provide any information about non-fossilizable attributes of the ancestors of mammals.

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1. Pickford, R. W., 1963 *Eugen. Rev.* **55**, 97.
2. Mather, K., 1955 *Evolution* **9**, 52.
3. Thoday, J. M., 1962 *Eugen. Rev.* **54**, 195.

Professor R. W. Pickford writes: I am very grateful for Professor Thoday's extremely interesting comments about my article on Natural Selection and Colour Blindness, and I hope that they will lead to further study of all the problems involved.

Dr. R. H. Post is, I believe, planning some experimental tests on possible disadvantages of colour blindness in certain situations, and the results of such experiments will be very interesting when they are published.

One point in Professor Thoday's letter might be mentioned, however. Total colour blindness is extremely rare, and I believe it was not under discussion, although experiments using totally colour blind and normal persons, and black and white photographs for comparison with colour photographs, would be very interesting. The most important experiments would be with pictures or scenes which imitated the colours believed to be seen by the several types of red-green defective persons, for comparison with normally coloured pictures or scenes in collaboration with subjects who had normal colour vision.

It is interesting that the less incapacitating forms of red-green colour vision defect are the more frequent, and the more serious defects less frequent, while total colour blindness, which is severely incapacitating, is very rare.

THE EUGENICS SOCIETY

To the Editor, The Eugenics Review

Sir,—Dr. Blacker in his appreciation of the life and work of Miss Pocock, remarks on the sense of mission which formerly existed in the Society